infinitesimal distance perpendicularly across it to the next equipotential on either side of it; and through the divisional points draw curves, cutting the equipotentials at right angles. These curves are the stream lines. They and the $(n+1)$ closed equipotentials (including the infinitely conductive borders) divide the whole surface into $n\ m$ infinitesimal squares, if m be the number of divisions which we found in the equipotential. The arrows on the diagram show the general direction of the electric current in different parts of the complex circuit; each arrow representing it for the thin metal shell on either far or near side of the ideal section by the paper.

Considering carefully the stream-lines in the neighbourhoods of the four open lips marked in order of the stream 1, 2, 3, 4, we see that for each of these lips there is one stream-line which strikes it perpendicularly on one side and leaves it perpendicularly on the other, and which I call the flux-shed-line (or, for brevity, the flux-shed) for the lip to which it belongs. The stream-lines infinitely near to the flux-shed, on its two sides, pass infinitely close round the two sides of the lip, and come in infinitely near to the continuation of the flux-shed on its two sides. Let F_1, F_2, F_3, F_4 (not shown on the diagram) be the points on the + terminal lip from which the flux-sheds of the lips 1, 2, 3, 4 proceed; and let G_1, G_2, G_3, G_4, be the points at which they fall on the − lip. Let S_1, T_1, S_2, T_2, &c., denote the points on the four lips at which they are struck and left by their flux-shed-lines.

Let p_1, l_1, p_2, l_2, p_3, l_3, p_4, l_4, p_5 be the differences of potential from the + lip to S_1, from S_1 to T_1, T_1 to S_2, ... S_4 to T_4, and T_4 to the − lip. Measure these nine differences of potential. We are now ready to make the Mercator chart. We might indeed have done so without these elaborate considerations and measurements, simply by following the rule of my previous article; but the chart so obtained would have infinite contraction at eight points, the points corresponding to S_1, T_1, ... S_4, T_4. This fault is avoided, and a finite chart showing the whole surface on a finite scale in every part is obtained by the following process.

Take a long cylindric tube of thin sheet metal, of the same thickness and conductivity as that of our original surface; and on any circle H round it, mark four points, h_1, h_2, h_3, h_4, at consecutive distances along its circumference proportional respectively to the numbers of the m stream-lines which we find between F_1 and F_2, F_2 and F_3, F_3 and F_4, F_4 and F_1 on the + lip of our original surface. Through h_1, h_2, h_3, h_4 draw lines parallel to the axis of the cylinder.

Let now an electric current equal to the total current which we had from the + lip to the − lip through the original surface be maintained through our present cylinder by a voltaic battery with electrodes applied to places on the cylinder very far distant on the two sides of the circle H. Mark on the cylinder eight circles, K_1, K_2... K_8, at distances consecutively proportional to l_1, p_2, l_2, p_3, l_3, p_4, l_4, and absolutely such that l_1, p_1, &c., are equal to the differences of their potentials from one another in order.

Bore four small holes in the metal between the circles K_1 and K_2, K_3 and K_4, K_5 and K_6, K_7 and K_8 on the parallel straight lines through h_1, h_2, h_3, h_4, respectively. Enlarge these holes and alter their positions, so that the altered stream-lines through h_1, h_2, h_3, h_4 (these points supposed fixed and very distant) shall still be their flux-sheds. While always maintaining this condition, enlarge the holes and alter their positions until the extreme differences of potential in their lips become l_1, l_2, l_3, l_4, and the differences of potential between the lips in succession become p_2, p_3, p_4. In thus continuously changing the holes we might change their shapes arbitrarily; but to fix our ideas, we may suppose them to be always made circular. This makes the problem determinate, except the distance from the circle H of the hole nearest to it, which may be anything we pleased, provided it is very large in proportion to the diameter of the cylinder.

The determinate problem thus proposed is clearly possible, and the solution is clearly unique. It is of a highly transcendental character, viewed as a problem for mathematical analysis; but an obvious method of "trial and error" gives its solution by electric measurement, with quite a moderate amount of labour if moderate accuracy suffices.

When the holes have been finally adjusted to fulfil our conditions, draw by aid of the voltmeter and movable electrodes, the equipotentials, for p_1 above the greatest potential of lip 1, and for p_5 below the least potential of lip 4; and between these equipotentials, which we shall call f and g, draw n-1 equidifferent equipotentials. Draw the stream-lines, making infinitesimal squares with these according to the rule given above in the present article. It will be found that the number of the stream-lines is m, the same as on our original surface, and the whole number of infinitesimal squares on the cylinder between f and g is $m\ n$. Cut the cylinder through at f and g; cut it open by any stream-line from f to g, and open it out flat. We thus have a Mercator chart bounded by four curves cutting one another at right angles, and divided into $m\ n$ infinitesimal squares, corresponding individually to the $m\ n$ squares into which we divided the original surface by our first electric process. In this chart there are four circular blanks corresponding to the lips 1, 2, 3, 4 of our diagram; and there is exact correspondence of their flux-sheds and neighbouring stream-lines, and of the disturbances, which they produce in the equipotentials, with the analogous features at the lips of the original surface as cut for our process. The solution of this geometrical problem was a necessity for the dynamical problem with which I have been occupied, and this is my excuse for working it out; though it might be considered as devoid of interest in itself.

KELVIN.

THE RECENT ERUPTION OF ETNA.[1]

THE southern flank of Etna has been the site of three consecutive eruptions, remarkable for the diversity of the phenomena they presented.

On March 22, 1883, after several violent shocks of earthquake, the ground was rent open in a N.E. and S.W. direction, almost on the continuation of the big rift formed in the eruption of 1879, and near Monte Concilio a most interesting eruptive apparatus was formed. Very quickly, however, the eruption was arrested, but the eruptive energy had not had sufficient vent, as evidence of which were the frequent shocks which followed it and persisted, until on March 18, 1886, the ground was again split open as a prolongation of the rift of 1883, giving rise to an imposing eruption, during which an enormous quantity of lava was poured forth. This eruption from the very beginning manifested a great explosive force. The fragmentary materials were projected to an extraordinary height from several craterets formed along the rift, most of which, however, soon became quiet and were buried by the ejectamenta of the others, remaining alone the one twin crater now called Monte Gemmellaro. After this eruption the geodynamic phenomena and the volcanic activity at the central crater remained exceedingly feeble up to the last few days, so that this actual eruption did not present any grand display of premonitory phenomena.

On the evening of July 8, at about 10.30, the central crater of Etna began to send up a dense column of vapour, charged with dust, lapilli, and large rock fragments, which rose as an imposing mass with the characteristic pine-shape of explosive eruptions, and illuminated by lightnings.

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[1] This paper was written in Italian, and sent as a letter to Dr. H. J. Johnston-Lavis, who has kindly translated it for NATURE, as requested by the author.

After half an hour this phenomenon ceased, and the smoke-plume was swept away by the higher currents of the atmosphere. I was able to ascertain in my excursion to the summit of Etna, in company with Mr. Rudler, curator of the Museum of Practical Geology of London, that the central crater was much modified by the short eruption. It presented two mouths, separated by a partition, whilst its upper edge was much broken down, so that it was enlarged. The ejected materials were composed of fragments of very much altered lavas that fell chiefly to the westward. During the night the ground was in a state of tremor, and at 2.45 a.m. of the 9th, a strong shock of earthquake was felt all over the Etnean region, producing slight damage to the walls of buildings.

Towards 1.20 p.m., without any further shock sensible in the inhabited regions, the southern flank of Etna was rent open, and I could observe from Acireale a dense curtain of smoke rush up in great vortices, accompanied by continual rumblings. Towards evening one could see that the lava had advanced very rapidly in a southern direction. At the upper part it was observable that several jets, arranged in a linear manner, of fragmentary materials were being shot up to a great height, especially at three main points on the new and great rift. The explosive force of this eruption was much less than that of the eruption of 1886, in which the fragmentary ejecta were shot up to a height of 1200 metres, whilst in the present case the height rarely exceeded 500 metres. This fact depends on the great altitude and the great size of the new fissure, which afforded a free escape for the energy of the volcano, and gave forth a much greater quantity of lava. The lava in less than three days travelled more than four kilometres, and having surrounded Monte Nero, which is to the south of the new craters, it divided in two principal branches and precipitated itself on the plain from which rises Monte Gemmellaro, forming three cascades of living fire. It here spread out, and the two branches, directing their course to the south, threatened Nicolosi, Belpasso, and Pedara. The more eastern ramification, when it reached the neighbourhood of Monte Albano, began to slow down and was already on the 12th advancing about two metres per hour, but increasing the breadth of its front and its thickness. On the other hand the western branch, which was invading the cultivated land, advanced in the steeper ground over fifty metres the hour, as I observed in my first visit on July 11. This stream was of a bright red colour, slightly covered by scoria. Near Monte Concilio it had filled up a valley, assuming a thickness of over 40 m. From Monte Ardicazzi we had presented to our view an immense expanse of fire from which rose crests and hills all incandescent, divided by deep depressions. It appeared like the sea in a tempest, the waves of which in their fury were suddenly petrified. From the crests were constantly being detached fresh incandescent masses which rolled down and choked the depressions, whilst new gushes raised the masses of scoria into new hills of fire. Amidst the phonolitic noise of the lava in movement, I noticed gigantic puffings produced by the escape of the vapour of H_2O, which, accumulating amidst the mass of the lava, formed gigantic bubbles which rose and burst, allowing the escape of the compressed gas.

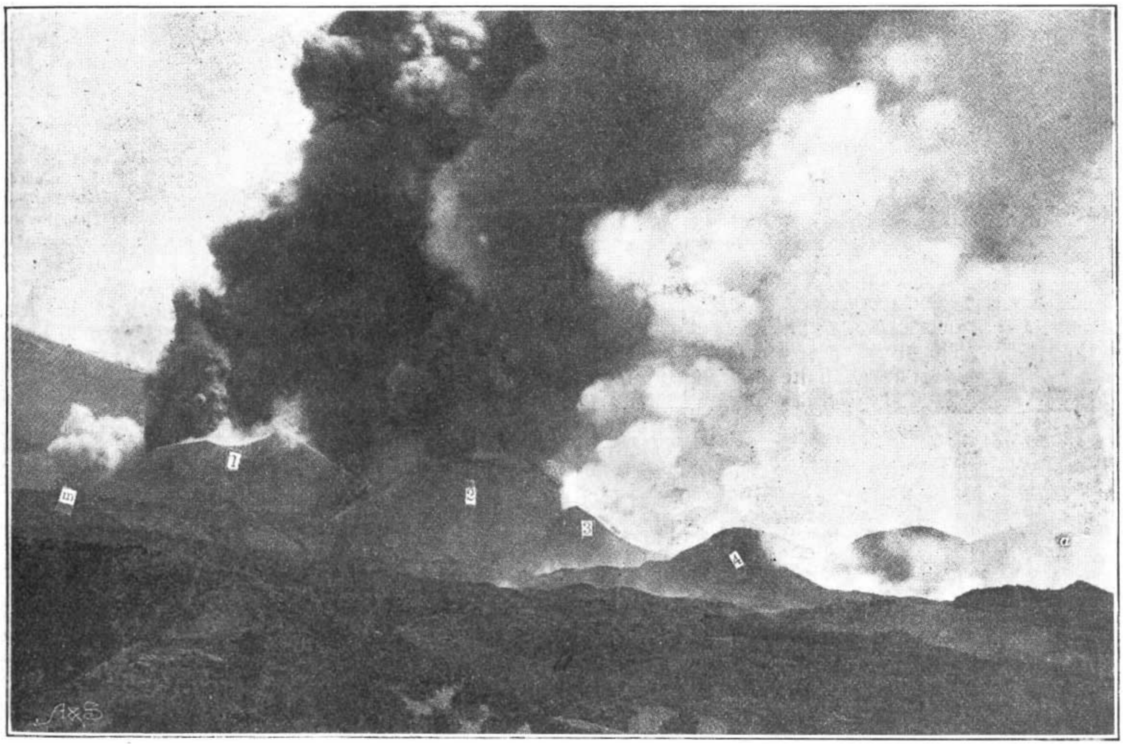

FIG. 1.—Taken by Sig. Ledrù on July 17 (No. 1, 2) are craters No. 1 and 2. (No. 3 and 4) craters No. 3 and 4 in process of formation.—(m) Crateriform vent at the north base of crater No. 1.—(a) Monte Nero about one km. west of the craters.

The eruption was very active during the following days with short intervals of diminution or marked increase. Remarkable phenomena were the blasts which shook the doors and windows at Nicolosi, Acireale, and Catania, and, at localities nearer the point of eruption, even the walls.

On July 16 I started again, with my brother Giovanni, to approach the site of eruption. From Monte Caprioletto, which is about 1200 m. distant, we could observe not only the three principal craters above mentioned, but also two others lower down, which so far had not grown to any important size.

Approaching still farther, we stopped at about 300 m. off on the west, on a plain upon which grows the *Astragalus Siculus*, the bushes of which are now covered by large lapilli, and in part are burnt. The crater, which for brevity we will call No. 1, gave forth large and continual bursts of dust and scoria from its summit, and also from other points on its northern wall, at the base of which issued a jet of light-grey vapour, which came from a little imbutiform crater separated from the main one by a partition of small size; from this were ejected a little dust and occasionally stones. The explosions of No. 1 were not accompanied by loud noises (*boati*, *bellowings*), but by strong and continual roarings like the sea in a tempest. Crater No. 2, more regular in form, gave forth frequent eruptions of dust, with many incandescent projectiles. In the moments of calm between one explosion and another, a slight white vapour escaped. The first burst of the explosion might be compared to a gigantic pointed jet preceded by black dust and sand, which rose with great rapidity in consequence of the great ascensional velocity, which was gradually impeded by the resistance of the air; then the column of black smoke charged with dust began to open out the immense vortices of compressed vapour which, always rising, assumed an imposing and characteristic aspect. The pieces of scoria were followed by a trail of dust both in their rise and fall, and when they struck the flanks of the mountain as they rolled down, they raised a cloud of dust and gave forth a characteristic sound. When they were numerous the mountain became all covered by a yellow dust.

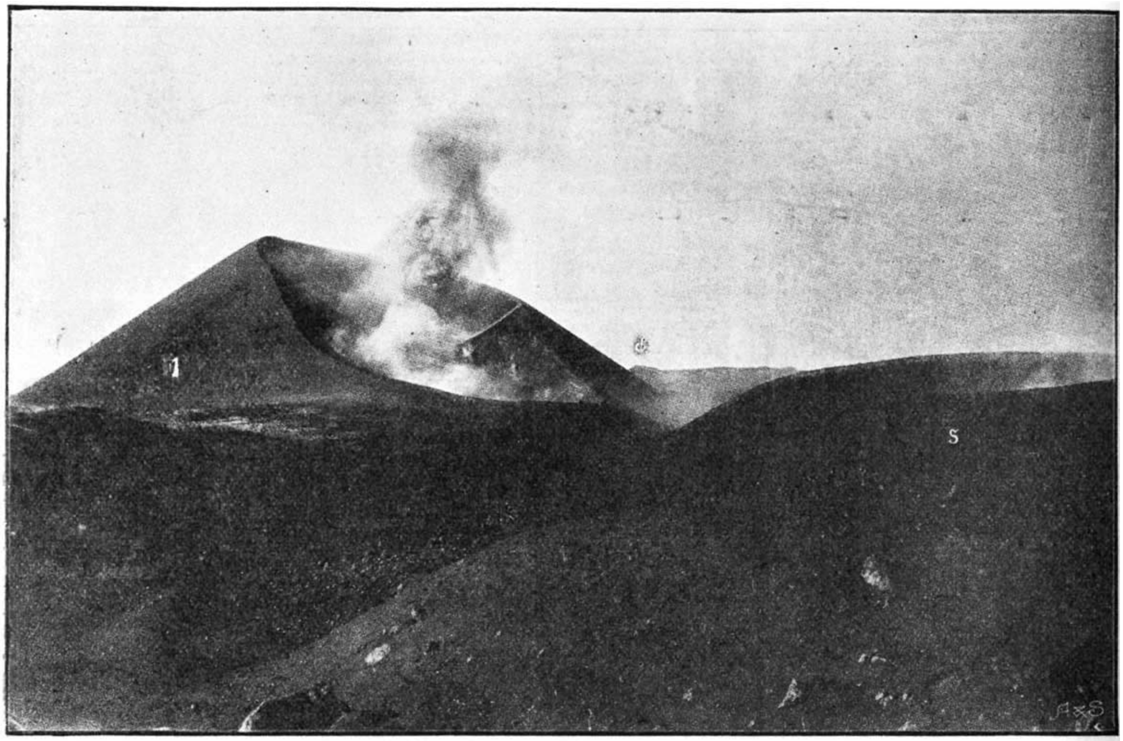

FIG. 2.—By Sig. Ledrù on August 19, at 100 m. to the north-east of the craters. (*S*) Crater of August 11. (*d*) Crater to the west which was in activity only on July 9. (1) Crater No. 1.

Also in this last crater the explosions took place from several points of its funnel-shaped cavity; and we saw, at about mid-day of the 17th, much of its southern side destroyed by several bursts that took place from that point.

Both of these craters, already of considerable height, had an elliptical base, and specially No. 1, the maximum diameter of which is in the direction of the great rift, along which they are distributed.

The third crater, which we will call No. 3, adjoining the preceding one, presents a large depression to the south. It gave forth frequent bursts of incandescent lava fragments, with a constant noise resembling the constant discharge of much musketry, and accompanied by yellowish-white vapours. The emission of dust was rare, and only occurred when the eruptive bursts scored the north side of the crater. The fragments of incandescent lava, which in this crater were not accompanied by a trail of dust, often were torn asunder in the air, being reduced to fragments.

The discharge of smoke from this crater occurred from the highest part, then there was the point at which occurred the numerous explosions of lava, then another jet of smoke, in its turn followed by another point lower down, from which occurred the explosions of the incandescent projectiles that gradually formed a crater, which we will distinguish as No. 4.

In general, while we were moving about to the westward of the craters on the morning of the 17th, the eruption was exhibiting comparatively little energy. Gradually, however, the explosions increased in violence, and the ejecta became more numerous. It is worthy of notice that the smoke, according to the place whence it issued was white, blue, light or dark grey, black, yellow, and even iridescent. Approaching nearer the craters, we attempted to encircle them on the north, when we found numerous little fissures in the ground in a direction approximately parallel to that of the main rift. These, often over a metre in breadth, are choked by the loose materials forming the surface, and in part obstructed by the loose materials forming their sides. Higher up we found a wide cleft, which, starting from a higher point, was prolonged downwards towards the craters and was lost beneath the lava. Upon this fissure were arranged a series of crateriform elevations, some of which were extinct, and others still presenting a little solfataric action. On July 9, at the commencement of the eruption, lava and fragmentary ejecta also issued by this cleft, but it seems, the same day, to have become obstructed, and the tongue of lava which menaced the Casa del Bosco stopped, and the eruptive phenomena were diverted to the other more eastern fissure.

It is absolutely impossible to accept the statement that this cleft represents the fire vents of the eruption of 1766, and that the solfataric phenomena which the cleft now exhibits are only due to the near vicinity of the new volcanic outlet, for—putting aside the fact that in visits anterior to the present eruption I had never found any sign of such, and this is confirmed by people accustomed to the locality—it is easy also to be convinced from the nature of the materials composing these craterets. These materials are so new as to leave no doubt as to their origin, and consist, those higher up, specially of blocks of old lava torn from the sides of the cleft; lower down they are principally scoria and other loose materials of recent formation.

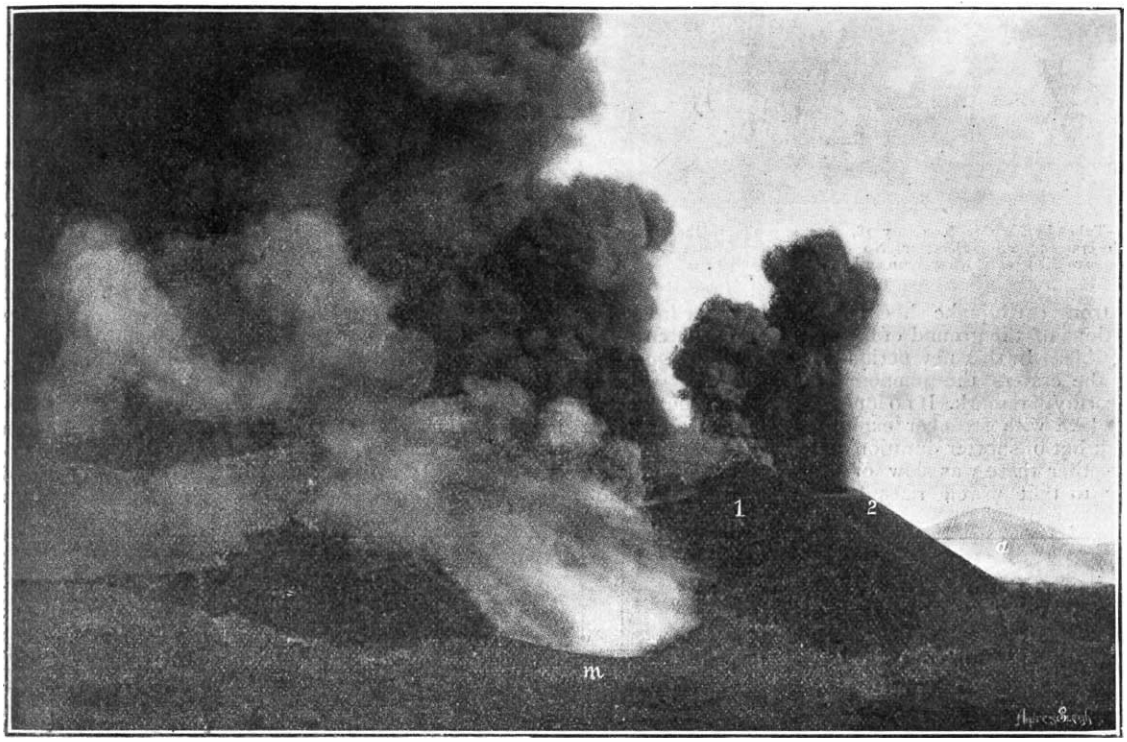

FIG. 3.—Taken by Sig. Modò on July 13, 1892, at 150 m. to the north-west of the craters. Craters No. 1 and 2. (*a*) Monte Nero. (*m*) Little northern crater.

Approaching still nearer, we were able to distinguish clearly that amongst the ejected materials of No. 1, besides the number of fragments of molten lava, there are often blocks of a dark grey colour that were already consolidated before their final ejection, which are either projectiles that have fallen back in the crater and have been re-ejected, or are pieces of rock detached from the walls of the volcanic chimney. Certainly from the last source are derived quartzites, which we collected amongst the ejected materials from this crater. This quartzite is semi-vitreous, very similar to that which we collected from the craters of the eruptions of 1883 and 1886. These facts evidently showed that all these three eruptions have traversed similar strata and that all have arisen over the same principal cleft. In fact the new eruptive apparatus formed at the base of the Montagnola about 1900 m. above sea level, lies on the northern prolongation of the rift of 1886, in a plain gently inclined toward the south, and which towards the east presents a marked slope, so that the new craters are much higher on their eastern side. In the great paroxysmal eruptions, and when a large rift opens at the surface of the earth, it is generally the rule that the eruptive mouth from which the lava flows without much explosive force is situated at its lowest extremity. The higher one goes along the fissure the less is the amount of lava that issues, but the greater is the explosive action, which higher still itself in turn diminishes. In the present eruption we have good examples of this. In fact, the small northern crater gave forth only dust, and very few fragments of new lava, and with little energy. No. 1 crater emitted much dust and also much lava; No. 2 more lava than dust, and Nos. 3 and 4 exclusively lava. The materials of the little northern crater (Fig. 3) are for the most part fragments of ancient lava, which lose their predominance in crater No. 1, and gradually disappear as one descends lower and lower. At the same time, as the old lava has a light bluish-grey colour and the fragments of the newer lava are much darker, the different craters exhibit different colours. This difference also depends in part upon the degree of fineness of the materials that compose the craters. In fact the northernmost crater at the beginning of the rift had not sufficient power to eject large materials, but lifted them up and kept them in continual movement, reducing them to fine dust, which was easily carried out by the vapour. No. 3, on the contrary, continually ejected large lumps of lava, often shooting them a considerable distance, whilst Nos. 1 and 2 exhibited intermediate stages, quite confirming what has been said above.

Whilst we were there the eruption increased little by little. The ground commenced to vibrate, and at 3.47 p.m. we felt a strong earthquake shock, followed by other frequent oscillations of the ground of less intensity but often very perceptible. In this new period of great activity general to all the craters the phenomena exhibited by No. 2 were worthy of remark. It no longer ejected dust, but pieces of hot lava with stronger explosions, which were more frequent but of shorter duration. Between one explosion and another there was slow evolution of white vapour, similar to that which rises from the fire-mouths and surface of the running lava. This floated above the crater, slightly disturbed by the wind, and when an explosion occurred it assumed a curious vibratory movement, rising a little, and then rapidly descending; then immediately was seen the first jet of solid materials, which, in its vertiginous upward course by vortex movement, sucked in the air over the crater edge, and the white vapours were drawn down, so looking as if they were being reabsorbed. This phenomenon, which attracted our attention when I was with you on Stromboli and the members of the Geologists Association,[1] would show that within crater No. 2 there is pasty lava, which is pushed up by the vapour in it; then the magma swells up, bursts, and the lava falls.[2]

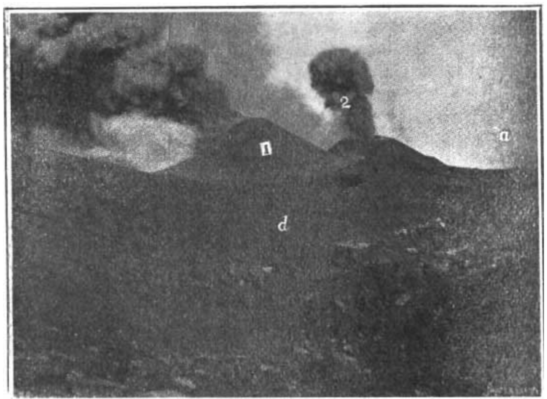

Fig. 4.—Taken by Sig. Modò on July 18, 1892, at 300 m. to the north-west of the craters. (1 and 2) craters No. 1 and 2. (*a*) Monte Nero. (*d*) Craters to the west which were in activity only on July 9.

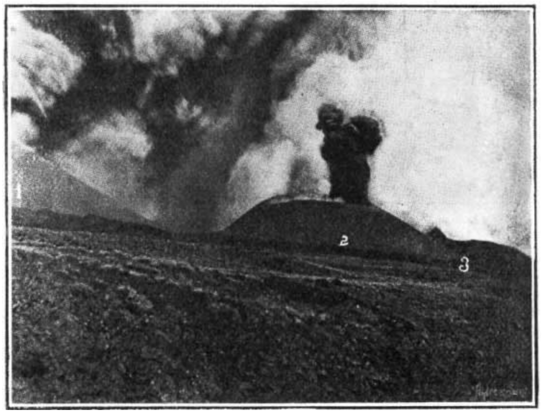

Fig. 5.—Taken by Prof. Riccò on July 20, west of the craters. (1, 2, 3), craters No. 1, 2, and 3.

In this parasitic crater of Etna, however, the phenomena were on a much larger scale, as also were the smoke vortex rings which we looked down upon when we were together at Stromboli. Likewise the explosions were far louder, reverberating as a low-pitched roar by the echo of the valleys, and they were audible in all the Etnean region, at Catania, Acireale, Giarre, and farther still for some dozens of kilometres from the craters. The air-shocks that accompanied these reports were very interesting. They represented a large undulation of the air, spreading with great velocity, reaching great distances, and contemporaneous with the audible vibrations.[3] While there, we felt the blow on our bodies, and especially our chests and in the ears; at the Casa del Bosco we detected the shock against the walls, which trembled, and farther off at Catania and Acireale we heard the rattling of the windows and doors, which, strongly shaken,

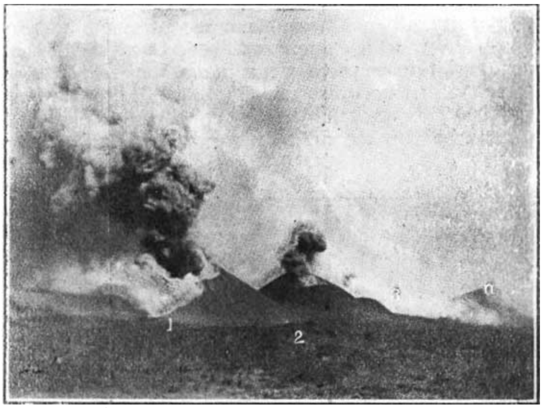

Fig. 6.—Taken by Prof. Riccò on July 20, to the north-west of the crater No. 1, 2, and 3. (*a*) Monte Nero.

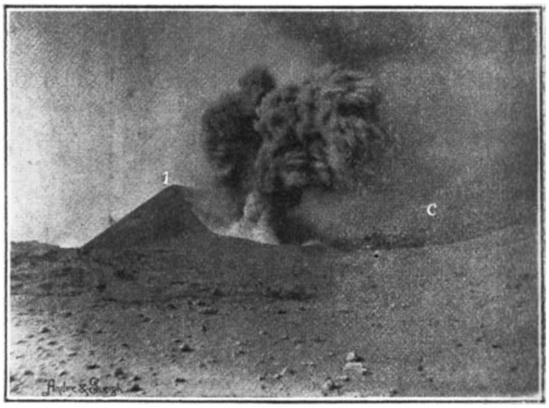

Fig. 7.—Taken by G. Platania from the north-north-east of the craters, July 30, 1892. (*1*) Crater No. 1. (*c*) Craters which were in activity only on July 9. The craters No. 2, 3, and 4 are hidden behind crater No. 1.

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[1] G. Platania "Stromboli e Vulcano, nel Settembre del 1889. Riposto 1889." This phenomenon I have often observed at Vesuvius, and I quite agree with Signor Platania as to its cause, as I have been able to look into the crater and watch the whole process.—Johnston-Lavis.

[2] The lava in this case is very like the boiling up of a viscous liquid in a long test-tube.—Johnston-Lavis.

[3] I have some doubts about the two mechanical disturbances travelling exactly at the same rate. When blasts are fired in a long tunnel the air-stroke is felt before the sound.—Johnston-Lavis.

give the impression of an earthquake, so that several times the people of these towns have rushed out into the streets. On July 14 I observed in Acireale that the large undulations of the air-blows which were propagated beyond 333 m. per second, like sonorous vibrations, often arrived unaccompanied by noise, and strongly shook doors and windows.

These reports, these air-blows, and the abundant ejection of incandescent lava still further prove that in No. 2 crater there was pasty lava which swelled and burst, as we deduced from its effect on the white vapours.

This period of great activity, in which the thick shower of lava fragments projected from the different craters to great heights. and spread over an area of 500m. radius, reached its maximum about midnight, and then gently declined a little. In the same manner the eruption continued during the following days with great energy, but with a very gradual diminution in its intensity, interrupted more or less by strong spasms. The lava continued to advance, but diminished in velocity, while it extended in breadth and depth. The eastern branch very soon stopped, and also the western one, after having continued its destruction of very fertile ground. This having crossed the road known as the St. Leo, finally stopped, whilst the new lava that continues to issue forms new ramifications and flows, which pass quite close to the earlier ones, and now actually are in contact with them, increasing the area covered. In the first paroxysm of the eruption the lava issued in great gushes all along the rift. Soon at the upper part commenced the dejection cones, and lower down the fire vents, and the lava flowed in abundance, and with explosions also in points where now are the craters, as, for example, Nos. 3 and 4. Later, when the explosive force had diminished, the lava issued without explosions, almost silently from different vents at the south end of the fissure on which are aligned the craters. These vents, therefore, have during the eruption varied in number and form. Some have assumed the function of dejection craters as occurred in Nos. 3 and 4, which gave passage to much lava as a current. Others have ceased to eject scoria, to send forth only torrents of lava, as, for example, the little mouth to the east of No. 4, the scoria rim of which exists only to the north, of about 20m. high, whilst the south rim has been swept away by the current. Some of the mouths have been refilled by the lava flows, and whilst some have become extinct new ones have been formed.

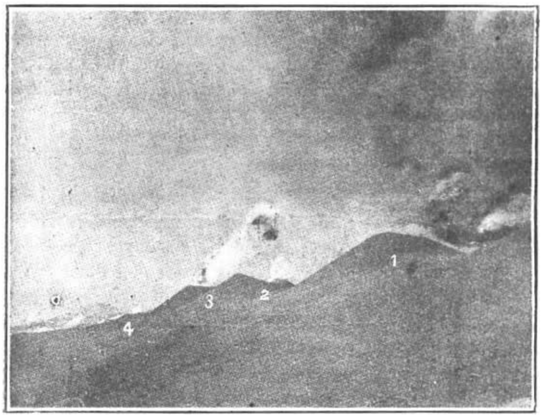

FIG. 8.—Taken by G. Platania on July 30 from the north-east of the craters, No. 4 is still very little, but in part hidden behind a prominence of the ground.

In the last week of July, crater No. 2 assumed, for some days, a new phase. Its explosions had become rare, long, and very grand, and the large mass of vapour, mixed with dust, brought back to my mind the eruption of Vulcano when we stood on the crater edge and watched and photographed the whole process, and stood our ground amidst showers of bombs and other projectiles (1888–90).[1] By this it lost the beautiful regular truncated cone form that it had at the beginning, and became irregular and broken-down towards the north, like No. 1.

At the commencement of August the eruption already seemed much diminished, craters No. 1 and 2 had ceased to eject stones little by little, gradually becoming blocked, and the enclosed lava was slowly cooling. In fact, on the recommencement of a period of renewed energy, the explosive force could no longer find an escape by them, so that on August 1 a new crater opened in a point higher up where the cleft to the west, which had only acted at the commencement of the eruption, joined another great rift on which the craters were formed. Then on August 9 occurred another violent eruptive spasm, which could not clear away the material that obstructed the craters, but opened a new way, always on the main cleft, between Nos. 1 and 2, and exactly at the north base of the last of these craters. Here a little funnel-shaped depression was formed which for a short time ejected enormous masses. This new crater, however, soon passed into the solfataric stage as Nos. 1, 2, and 3, and there remained in an energetic state of activity only the crater of August 11 and No. 4. That one which on August 21 measured in diameter only about 50 m., and had a height of about 60 m., later became elongated towards the S.S.W., and its grand and beautiful explosions, which I watched quite closely, in company with Mr. Rudler, on August 29, 30, and 31, were specially localized on the southern edge, so that they tended all the more to give it an elongated form on that more western cleft that was only in activity the first days of the eruption. No. 4, meanwhile, which I approached, ascending upon No. 3, gave forth frequent eruptions of hot lava cakes at regular intervals (about fifty per minute), accompanied by globes of yellowish vapour, and a noise similar to that which accompanies the globes of vapour from the locomotive when it commences to move.

By unanimous consent of all the studious inhabitants of Etna, the new craters have been called the Monti Silvestri, in honour of that well-known vulcanologist, the lamented Prof. Orazio Silvestri, who studied our volcano with so much fervour, registered so assiduously every slight disturbance, and described its paroxysms so well and with such originality, that his loss has been deeply felt by all men of science. GAETANO PLATANIA.

14, Via S. Giuseppe, Acireale,
September 7.

NOTES.

THE Harveian oration will be delivered by Dr. J. H. Bridges at the Royal College of Physicians on Tuesday, October 18, at four o'clock.

THE Medical Session in London was opened on Monday, and introductory addresses were delivered in some of the schools attached to hospitals. A particularly interesting and suggestive address was delivered at the Westminster Hospital by Dr. Mercier, who dealt with various aspects of the problems connected with crime, pauperism, and insanity. Sir John Lubbock addressed the students at St. Thomas's Hospital.

ON Friday last Sir George Murray Humphry, F.R.S., delivered an interesting address at the opening of the first session

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[1] "South Italian Volcanoes," by Johnston-Lavis, Naples, 1891. "I Projettili Squarciati di Vulcano," by G. Platania. (Roma, 1891.)